TITLE OF THE INVENTION

WATERPROOF STRUCTURE PROVIDED ON DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2003-077714, filed March 20, 2003, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a waterproof structure that is provided on a device for outdoor use and prevents entrance of water from outside.

2. Description of the Related Art

In general, portable devices are frequently used outdoors, and measures are taken to prevent damage due to shock in case of drop, or the like, and to prevent entrance of dust, water, etc. Of these measures, waterproofing is realized in the following manner. An elastic member of, e.g. rubber is interposed in a collapsed state, for example, at an entire coupling part between casings of a structure that comprises a plurality of divided casings, at an entire coupling part between a detachable cover, such as a battery chamber cover, and a casing, or at an entire coupling part between a display screen of, e.g. a liquid crystal display, and an opening part of a casing. Thereby,

entrance of external water can be prevented.

For example, the following waterproof technique is known. A projection rib is provided along the entirety of a coupling part of one casing, and a grooved rib is provided along the entirety of a coupling part of the mating casing. An O-ring is fitted in a groove formed in the grooved rib. In assembly, the projection rib is engaged with the grooved rib, and the O-ring is elastically deformed, thus preventing entrance of water from outside. Jpn. U.M. Appln. KOKAI Publication No. 61-50947, for instance, discloses that a waterproof packing, as well as the O-ring, can be used.

In the technique disclosed in this prior-art document, the O-ring for preventing water leak and the waterproof packing have annular shapes. Thus, these are formed using a pair of molds. Consequently, there are two projecting flashes (parting lines) along the coupling part of the molds. In many cases, flashes form on an inside part and an outside part of the O-ring. In a case where the O-ring is used and is put in tight contact state between upper and lower sides, waterproof is effected if the O-ring 42 is fitted in the groove 41a on the grooved rib 41 such that flashes 42a are present on both sides of a groove 41a, as shown in FIG. 10. However, if the O-ring 42 is twisted when it is fitted in the groove 41a, and the flashes 42a are turned toward the upper and lower sides, as shown in

FIGS. 11A and 11B, water that is splashed from outside would enter via the flashes 42a. However, if the flashes 42a are removed by secondary processing, even if the O-ring 42 is fitted in the groove in the twisted state, entrance of water could be prevented.

BRIEF SUMMARY OF THE INVENTION

The present invention may provide a waterproof structure that is provided on a device, comprising: a waterproof member that is interposed between a first member and a second member and is put in close contact with the first member and the second member by elastic deformation, thereby effecting waterproofing, wherein the waterproof member is a pipe that is formed by extrusion-molding a material with elasticity and anti-permeation properties, terminal-end faces of the pipe are disposed to be opposed to each other with their centers (axes) being aligned, and the pipe is extended by pressure that acts when the first member and the second member are engaged or attached to each other, whereby the terminal-end faces of the pipe are brought into close contact with each other and waterproofing is effected.

The invention may also provide a waterproof structure that is provided on a device, comprising: a waterproof member that is interposed between a first member and a second member and is put in close contact with the first member and the second member by elastic

deformation, thereby effecting waterproofing, wherein the waterproof member is a pipe that is formed by extrusion-molding a material with elasticity and anti-permeation properties, and has terminal-end faces at both ends, the first member is formed as an outer L-rib having a close-contact face at a wall face thereof, and the second member is formed as an inner L-rib that is engaged with the outer L-rib, and the pipe is fitted on an inner wall face of the outer L-rib such that the terminal-end faces of the pipe are opposed to each other at a distance with their centers (axes) being aligned, and the pipe is extended along the inner wall face of the outer L-rib when an outer peripheral surface of the pipe is pressed by engagement between the first member and the second member, whereby the terminal-end faces of the pipe are brought into close contact with each other.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1A shows a cross-sectional structure of a coupling part in a waterproof structure according to a first embodiment of the present invention, and FIG. 1B shows the state of arrangement of a pipe that is fitted in a grooved rib;

FIG. 2A shows the state of terminal-end faces of the pipe that is fitted in the grooved rib shown in FIGS. 1A and 1B, and FIG. 2B shows the state of contact between the terminal-end faces of the pipe when a

projection rib is engaged in the grooved rib;

FIG. 3A shows a cross-sectional structure of a coupling part in a waterproof structure according to a second embodiment of the invention, and FIG. 3B shows the state of arrangement of terminal-end portions of a pipe that is fitted in a grooved rib;

FIG. 4 shows a cross-sectional structure of a coupling part in a waterproof structure according to a third embodiment of the invention;

FIG. 5 shows a cross-sectional structure of a coupling part in a waterproof structure according to a fourth embodiment of the invention;

FIG. 6 shows a cross-sectional structure of a coupling part in a waterproof structure according to a fifth embodiment of the invention;

FIG. 7 shows a cross-sectional structure of a coupling part in a waterproof structure according to a sixth embodiment of the invention;

FIG. 8 shows a cross-sectional structure of a coupling part in a waterproof structure according to a seventh embodiment of the invention;

FIG. 9 shows a cross-sectional structure of a coupling part in a waterproof structure according to an eighth embodiment of the invention;

FIG. 10 shows an example of a prior-art waterproof structure; and

FIGS. 11A and 11B are views for explaining a

problem of the prior-art waterproof structure.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will now be described with reference to the accompanying drawings.

A waterproof member that is used in a waterproof structure of the present invention is first described.

The waterproof member of the present invention is provided at coupling parts, for example, between casings of a structure that comprises a plurality of divided casings of, e.g. an electronic device, between a detachable cover, such as a battery chamber cover, and a casing, and between a display screen of, e.g. a liquid crystal display, and an opening part of a casing. Thereby, the waterproof member prevents permeation of water or seawater from outside.

The waterproof member is formed of, for example, a hollow cylinder (pipe) that is produced by extrusion-molding a material with elasticity and anti-permeation properties, e.g. rubbers including a synthetic rubber such as silicone rubber, or resins. The pipe may take a variety of cross-sectional shapes, e.g. a circular shape (perfect circle), oval shape, rectangular shape, polygonal shape, star-shape (to be described later), etc. The diameter, thickness, etc. of the pipe are properly changed in accordance with design of a device to which this waterproof member is applied. The thickness may be uniform, or may be varied from

location to location in consideration of the collapsed state of the pipe so that the pipe may include thick portions and thin portions. For example, in the case of a pipe with a track shape, the thickness of straight portion of the pipe may be increased, as desired.

The merit of the use of this pipe is that a greater stroke of deformation (range of deformation in a waterproof state) is obtained than in the case of the O-ring when the pipe is deformed (collapsed) in a diametrical direction by pressing. Since the conventional O-ring is solid, the volume change of the O-ring is small when it is pressed. By contrast, the hollow part of the pipe undergoes a volume change. Accordingly, even if the state of collapsing varies, the state of tight contact hardly changes and the waterproof function can be performed. In addition, by virtue of the presence of the hollow part, the reaction force of the pipe, which corresponds to the amount of collapsing by the casing (member to be waterproofed), is made less than in the case of the O-ring. Moreover, since the pipe is fabricated by extrusion molding, the cross-sectional shape of the pipe can freely be chosen, and there is no flash of a parting line on the surface of the pipe.

Since the pipe of this invention has a longer deformation stroke and a weaker reaction force than the prior-art O-ring, a variation in amount of collapsing

due to non-uniformity in dimension of the casing can be canceled as a tolerable one and there arises no problem of water permeation or deformation of the casing. In other words, since the tolerable range of pressing is greater than in the case of the O-ring, it is easier to manage the precision of molds and the dimensions of the coupling part (configured by the projection rib and grooved rib) between casings, and this is advantageous in terms of cost. This pipe has no flash along a parting line. Even if the pipe is twisted when it is fitted in the grooved rib, sure waterproofing can be realized with no problem.

This waterproof member does not have a closed-circular shape (ring shape). The waterproof member is used as a pipe with two terminal-end faces. The O-ring, which has no terminal-end face, has no connection portion, and there is no possibility of water leak at such a connection portion. In the case of the pipe, if there is a gap between the terminal-end faces, there is a possibility of water leak.

To solve this problem, when the pipe is being pressed by engagement between both ribs, the terminal-end faces of the pipe are brought into close contact with each other, with no gap being created therebetween. Alternatively, both terminal-end portions are juxtaposed (superposed on each other) in the circumferential direction so that side faces of the

terminal-end portions are put in close contact with each other, with no gap being created in use.

FIGS. 1A and 1B and FIGS. 2A and 2B show an example of a waterproof structure according to a first embodiment of the present invention.

FIG. 1A shows a cross-sectional structure wherein a pipe, which serves as a waterproof member, is interposed at a coupling part where a projection rib and a grooved rib are engaged with each other. FIG. 1B shows the state of arrangement of the pipe that is fitted in the grooved rib. FIG. 2A shows the state of terminal-end faces of the pipe that is fitted in the grooved rib, and FIG. 2B shows the state of contact between the terminal-end faces of the pipe when the projection rib is engaged in the grooved rib.

This waterproof structure includes a casing 1 and a casing 2. The casing 1 has an end portion provided with a projection rib 1a. The casing 2 has an end portion provided with a grooved rib 2a. The projection rib 1a and grooved rib 2a are formed such that a gap is provided on both lateral sides, when they are engaged.

As is shown in FIG. 1B, a pipe 3 is fitted in a groove of the grooved rib 2a. In this case, terminal-end faces 3a and 3b of the pipe 3 are opposed to each other such that their centers (axes) are coincident (i.e. coaxial) and a gap A is provided between the terminal-end faces 3a and 3b. The gap A, as shown

in FIG. 2B, is determined such that the gap A is eliminated when the projection rib 1a and grooved rib 2a are engaged, the pressed pipe 3 extends along the groove of the grooved rib 2a, and the terminal-end face 3a comes in contact with the terminal-end face 3b. For example, the gap A between the terminal-end faces becomes 0 mm on the experiments under the condition as follows:

the gap at the time of engagement is 0 mm, when hardness of rubber of the pipe

= Durometer 60 Shore A,

outside diameter = ϕ1 mm,

inside diameter = ϕ0.5 mm,

width of the groove of the grooved rib = 1 mm,

amount of collapsing due to engagement = 0.5 mm, and

gap between terminal-end faces = 0 to 1 mm.

The reason why said gap comes 0 is that the terminal-end portions of the pipe are extended and the terminal-end faces thereof contact each other, when the projection rib 1a and grooved rib 2a are engaged. With no gap remaining, seal is effected and the waterproof function is surely performed. From the actual measurement values, it is understood that the proper gap A between the terminal-end faces of the pipe, which is fitted in the groove of the grooved rib 2a, is 0 to 1 mm. It is easy to provide the gap A of 0 to 1 mm at

the time of work for fitting the pipe in the groove. However, this value varies depending on the diameter and material of the pipe, the shapes of ribs, external environment, etc. In consideration of this, in order to find an exact value, it is desirable not only to perform simulations, but also to actually fit the pipe in the groove at the time of manufacture.

There may be a case where even if the pipe is pressed, the pipe does not extend in the direction of the groove because of the quality of its material. In such a case, it is a possible method to put the terminal-end faces 3a and 3b in contact with each other, from the beginning, at the time of fitting the pipe in the groove.

As has been described above, according to the waterproof mechanism of this embodiment, the waterproof member that is formed of the elastic pipe has a long stroke of deformation and a weak reaction force. Thus, no problem arises even if the amount of collapsing of the pipe slightly increases due to a variance in dimension of the casings (projection rib and grooved rib). Compared to the prior-art O-ring, the tolerable range of pressing increases. This makes it easy to manage the precision of molds and the dimensions of the coupling part. An increase in cost for realizing high precision can be suppressed. Moreover, since there is no flash at a parting line, sure waterproofing is

achieved even if the pipe is twisted when it is fitted in the groove of the grooved rib.

FIG. 3A and FIG. 3B show an example of a waterproof structure according to a second embodiment of the invention.

FIG. 3A shows a cross-sectional structure of a coupling part between a projection rib and a grooved rib, where terminal-end portions of a pipe that functions as a waterproof member are juxtaposed. FIG. 3B shows the state of arrangement of terminal-end portions of the pipe that is fitted in the grooved rib.

In the above-described first embodiment, the terminal-end faces of the pipe 3 that functions as a waterproof member are put in close contact with each other, whereby the waterproof function is achieved. In the second embodiment, as shown in FIG. 3A, terminal-end portions 3c and 3d of the pipe 3 are juxtaposed (or superposed on each other) such that their axes are made parallel. Side faces of the juxtaposed terminal-end portions 3c and 3d of the pipe 3 are brought into close contact with each other, making use of their horizontal deformation that is caused by the pressing force acting when the projection rib 1a and grooved rib 2a of the casings 1 and 2 are engaged. Thereby, a sealing state without gap is maintained, and a sure waterproof function is achieved. In the meantime, when this arrangement is adopted, a hole in one of the two

terminal-end faces of the pipe can be collapsed and closed by, e.g. heating. In the present embodiment, too, the same advantages as with the above-described first embodiment can be obtained.

FIG. 4 shows an example of a waterproof structure according to a third embodiment of the present invention.

FIG. 4 shows a cross-sectional structure wherein a pipe 3 that functions as a waterproof member is clamped at a coupling part between an outer L-rib 4a of a casing 4 and a mating inner L-rib 5a of a casing 5. In the first and second embodiments, the pipe fitted in the groove (grooved) is pressed in the thickness direction by the projection. Thus, the pipe is deformed and put in close contact, and waterproof is effected. In the third embodiment, when the outer L-rib 4a and inner L-rib 5a are engaged, the interposed pipe 3 is pressed and deformed in the lateral direction and deformed, whereby waterproofing is achieved.

In the case of the above-mentioned pressing in the thickness direction, the degree of pressing varies depending on the depth of engagement between the projection rib 1a and grooved rib 2a. It is thus necessary to give consideration to realization of uniform depth of engagement. On the other hand, in the third embodiment, pressing in the lateral direction is used. Hence, similar pressing is realized even if the

depth of engagement of overlapped parts of both ribs increases or decreases due to a variance in length of projecting parts of both ribs or in depth of grooves. Therefore, even if an error in assembly occurs, the close contact state is hardly affected by the deformation of the pipe and is maintained.

FIG. 5 shows an example of a waterproof structure according to a fourth embodiment of the invention.

In each of the above-described embodiments, engagement is made between the projection-rib and grooved-rib or between L-ribs. In the fourth embodiment, at least one of two mating parts, between which there is a coupling part to be waterproofed, is flat, as in a case of engagement between a casing and a liquid crystal display screen.

In the waterproof structure of the fourth embodiment, a pipe 3 that functions as a waterproof member is disposed in a circular groove 6a that is formed in an LCD attachment surface at the opening of a casing 6. A display screen 7a of a liquid crystal display (LCD) 7 is fixed by, e.g. screws, using a display device holding member (not shown). The pipe 3 is pressed in the direction of the arrow. In this case, the pipe 3 is deformed by the pressing force that is produced by the fixation, and the circular groove 6a and display screen 7a are put in close contact. Waterproofing is thus achieved. In this embodiment,

the depth of the circular groove is adjusted, thereby to properly control the degree of collapsing of the pipe. This embodiment is applicable to not only a structure wherein only one of mating bodies is flat, but also to a waterproof structure between flat surfaces. In this case, however, a stopper, or the like, is provided between the flat surfaces so as to prevent excessive collapsing of the pipe. The provision of such a component ensures proper deformation of the pipe.

This waterproof structure is applicable to not only the screen of the LCD, but also to glass or mirror-finished metal. For instance, the waterproof structure may be applied to a window or a door that comprises a glass sheet and an aluminum sash. In addition, it may be applied to waterproofing between a glass sheet and a frame of a water tank or a show window.

FIG. 6 shows an example of a waterproof structure according to a fifth embodiment of the present invention.

In this waterproof structure, the coupling part to be waterproofed is configured such that a pipe is clamped between grooved ribs with circular grooves.

This waterproof structure is used, for example, for waterproofing between a flat member 8 and a flat member 9. The surfaces of the flat members 8 and 9 are

provided with circular grooves 8a and 9a, which are mated to press and collapse the pipe 3. When the flat surfaces of the flat members 8 and 9 are brought into contact with each other, the pipe 3 may possibly be collapsed excessively. Thus, the depth of each circular groove 8a, 9a is adjusted so as to properly control the degree of collapsing of the pipe 3 even when the flat members 8 and 9 are put in close contact with each other.

FIG. 7 shows an example of a waterproof structure according to a sixth embodiment of the present invention.

In the preceding embodiments, the cross section of the pipe has a perfect circular shape. However, since the pipe is formed by extrusion molding, it can be provided with a variety of cross-sectional shapes only by altering the nozzle shape of a molding machine.

In the sixth embodiment, as shown in FIG. 7, the cross section of a pipe 10 has a rectangular shape, for instance, a rectangular shape. If this shape is applied to the coupling part where the projection rib and grooved rib are to be engaged, twist of the pipe 10 hardly occurs when it is fitted in the groove of the grooved rib. Moreover, when the pipe 10 is clamped, the area of tight contact increases advantageously. Alternatively, the pipe 10 may have an oval shape, etc.

FIG. 8 shows an example of a waterproof structure

according to a seventh embodiment of the present invention.

In this embodiment, a pipe 11 has a splined cross-sectional shape. If this shape is applied to the coupling part where the projection rib and grooved rib are to be engaged, the pipe 10 can be fitted in the groove of the grooved rib with little twist. Even if twist occurs, the occurrence of such twist can easily be understood. Compared to the pipe with the perfect circular cross-sectional shape, the pipe 11 is advantageous in that water moves along the outer periphery of the pipe 11 and does not easily enter the inside.

FIG. 9 shows an example of a waterproof structure according to an eighth embodiment of the present invention.

In the above-described first embodiment, the pipe has a perfect circular cross section, which is obtained when the pipe is cut in a direction perpendicular to the center axis of the pipe. In this eighth embodiment, a pipe 12 has an oval cross section, which is obtained by cutting the pipe 12 in a direction oblique to the center axis of the pipe 12. Like the first embodiment, terminal-end faces with oval cross sections of the pipe 12 are disposed at a predetermined distance A. When the pipe 12 is pressed, the terminal-end faces are put in close contact with each other.

According to this embodiment, the area of close

contact increases, and the tight-contact state is improved. Hence, the waterproof effect is enhanced.

The waterproof member (pipe) of the waterproof structure of each of the above-described embodiments can easily applied to a variety of devices, in place of conventional O-rings and packing members. For example, the waterproof member is usable as a waterproof member provided on casings of portable devices, such as transparent waterproof cases for underwater use, which contains cameras, video cameras, etc. Additionally, the waterproof member is applicable as a waterproof member that is used when windshields (e.g. front window) of automobiles or headlight coves are attached, or when covers for street lights are attached.

The pipe that is the waterproof member of the present invention is effective not only for prevention of permeation of water, but also for prevention of leak of oil, liquid detergent, etc.

According to the present invention, as has been described above in detail, water leak via a flash of a waterproof member can be prevented. In addition, a tolerable range of amount of collapsing of the waterproof member is increased, and the required precision for formation of the coupling part of casings, on which the waterproof member is provided, is relaxed. Thus, the waterproof structure that ensures waterproofing can be provided.